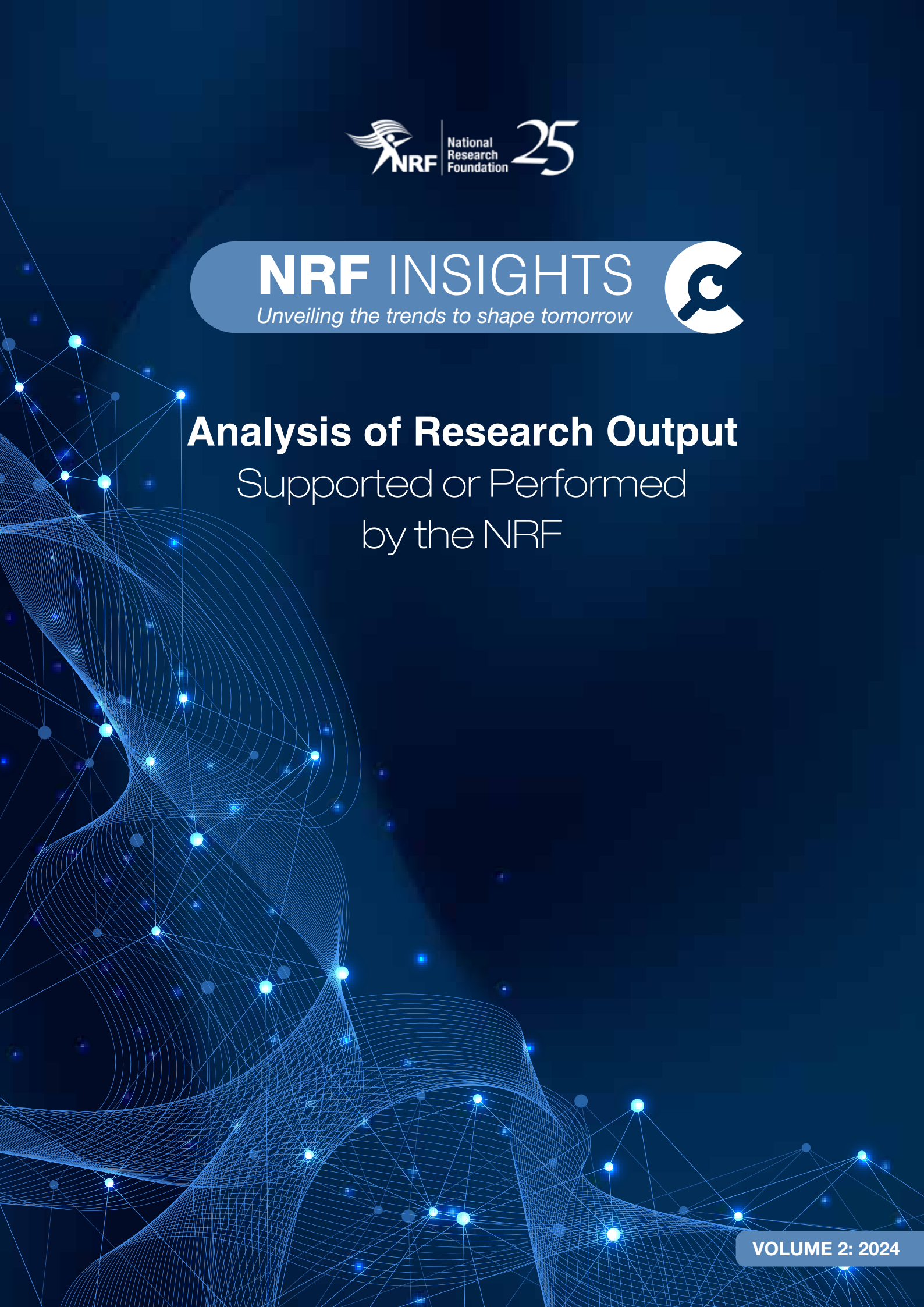
National Research Foundation 25

NRF INSIGHTS

Unveiling the trends to shape tomorrow



Analysis of Research Output Supported or Performed by the NRF

VOLUME 2: 2024

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Introduction

In this edition of *NRF Insights*, we provide data on the productivity of NRF-funded researchers. First, we consider the number of Web of Science (WoS) research publications produced by NRF-funded researchers (or enabled by NRF-supported research infrastructure and equipment) compared to all South African WoS research publications, and global WoS research publications.[1] Second, we analyse research aligned with the United Nations (UN) Sustainable Development Goals (SDGs), assessing both the number of South African and NRF-funded publications by SDG. Finally, the document considers WoS research publications by NRF National Research Facilities, which have increased by 20% since 2019, and key knowledge impact.[2]

Research Output Supported or Performed by the NRF

Research productivity (with quality assessment) is a recognised measure of researcher performance and the efficiency of a research system. Various journal indices can be used for the assessment of research performance, and the Department of Higher Education and Training (DHET) uses seven indices for research subsidy purposes.[3] The NRF uses the Clarivate (previously called Thomson Reuters) Web of Science (WoS) index for its analysis as it provides deep coverage and comprehensive indexing of journals in the Natural Sciences, Social Sciences, Arts and Humanities. Of all DHET subsidised journal articles published in 2022, just over 50% appeared in WoS indexed journals.[4]

To gauge the productivity of NRF-funded researchers, a comparative analysis of the WoS publications by each NRF-funded authors, all South African authors, and all global authors is shown in Figure 1. From 2022 to 2023, publications by NRF-supported researchers increased (13%), while South African and global publications decreased (by 4% and less than 1% respectively).

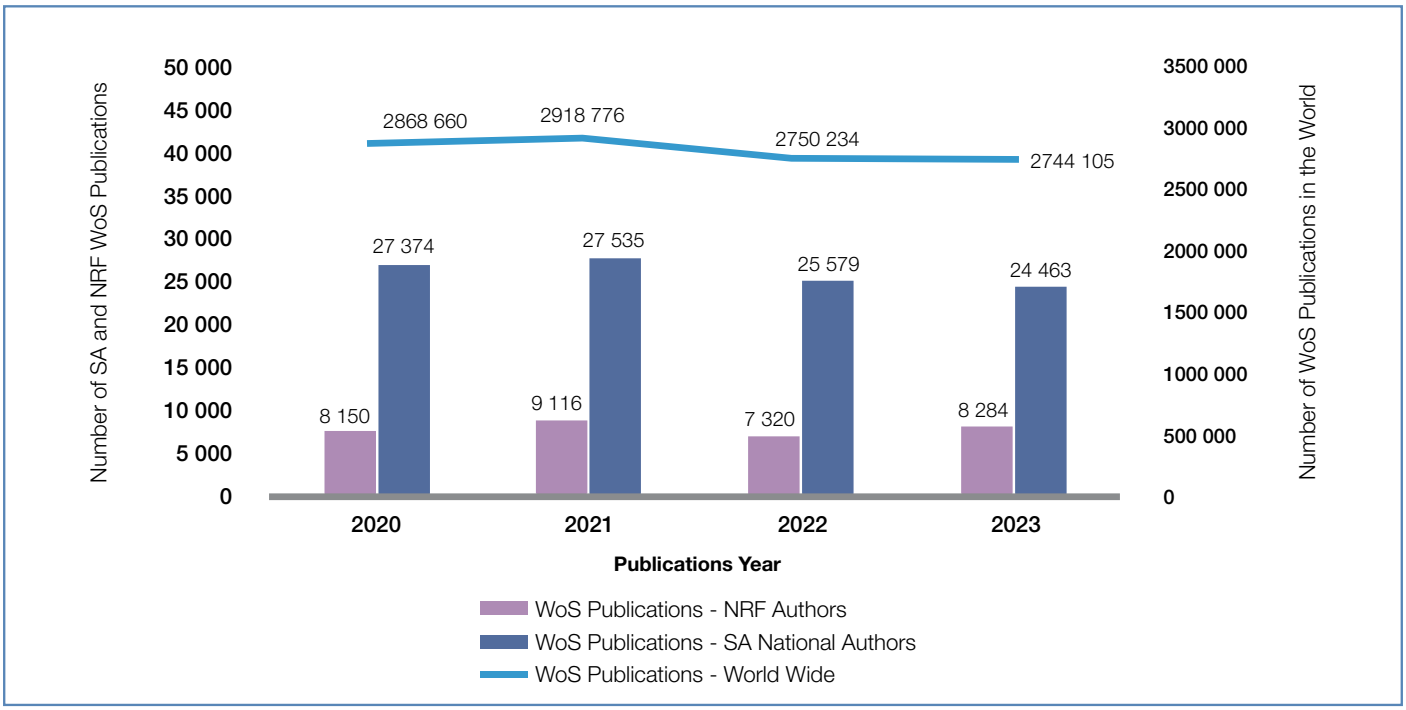


Figure 1: Number of Web of Science Publications, 2020 to 2023

1. The data is drawn from Clarivate Web of Science and reflects numbers on that specific day. Slight variations are evident depending on the day drawn. The number refers to WoS documents and not only research articles.
2. The data in this edition of NRF Insights covers calendar years, not financial years.
3. Scopus, the Scientific Electronic Library Online South Africa (SciELO SA), the Norwegian Register for Scientific Journals, the Clarivate (previously Thomson Reuters) Web of Science (WoS), the ProQuest International Bibliography of the Social Sciences (IBSS), the Directory of Open Access Journals (DOAJ), and the SA DHET index.
4. Department of Higher Education and Training (DHET). 2024. Report on the evaluation of the 2022 universities' research output.

NRF-funded researchers contributed 34% (8 284) of the total South African publications (24 463) in 2023, compared to 30% in 2020. This aligns closely with the proportion of NRF-funded permanent research and instruction staff with a doctorate. Using 2022 data, the latest DHET data available, the NRF funded 16% (3 323 researchers) of the permanent research and instruction staff cohort (20 612) and 35% of those with a doctorate (9 434). In 2020, the NRF funded 2 972 researchers, 15% of the staff cohort or 33% of those with a doctorate.[5]

Overall, the number of South African WoS publications has declined since 2020 (11%), but the shift is not of great concern given that publication output globally was high during the Covid-19 pandemic. Global WoS publications have declined by 4% since 2020. Publications by NRF-funded researchers have grown slightly (2%), which is notable given support for a declining number of researchers.[6]

Publications fields and priorities

Along with assessing the number of South African and NRF-funded publications, it is also important to consider the research area in which these are published. Globally, a key assessment tool is to map the proportion of publications that advance specific United Nations (UN) Sustainable Development Goals (SDGs). Research responding to SDG challenges highlights areas with potential for societal benefit and research impact. Given the wide range of SDGs, this includes research in areas such as health, climate change, poverty, education, gender and more. Some areas have greater importance for the developmental challenges faced in South Africa than others. The NRF first mapped NRF-funded WoS published research to SDGs in 2021, and since the exercise has been refined to reflect research across multiple SDG areas where relevant, as shown in Figure 2. There has been little change in the proportion of research per SDG compared to 2022.

In 2023, 79% of NRF-funded research publications were linked to one or more SDG. This aligns closely to all South African research, where the proportion was 77%. The analysis shows that by far the greatest NRF and South African research contribution is to SDG 3: Good Health and Well Being, highlighting the important role that research plays in response to health needs. Research institutions are working on improving access to health facilities and addressing health inequalities. This includes innovative approaches to healthcare delivery and disease prevention.[7] Other areas with concentrated research are SDG 13: Climate Action and SDG 15: Life on Land. These research focus areas highlight the current challenges being faced in terms of a changing climate and adapting to minimise its negative impact on South Africans. Climate action has also been integrate into national policies focused on both mitigation and adaptation strategies. Research in this area has highlighted the need for better institutional frameworks and coordination to effectively implement policies, and to align energy policies with climate mitigation goals. Ongoing challenges relate to energy-intensive industries that struggle to comply with existing policies.[8]

Given South Africa's developmental challenges, there are SDG areas where more research is needed to address persistent concerns. For instance, there is little research relating to SDG 1: No Poverty, SDG 5: Gender Equality, SDG 8: Decent Work and Economic Growth, SDG 10: Reduced Inequalities, and SDG 16: Peace, Justice and Strong Institutions. All of these are areas where research could play a significant role in improving the lives of ordinary South Africans, and more research is required in these areas. The SDG mapping exercise is important for the NRF in identifying areas where more funding is required, and this may inform future funding priorities to ensure a greater focus on research with potential for societal benefit. Universities and research centres are also integrating SDGs into their curricula and research agendas. This helps in raising awareness and equipping future leaders with the knowledge to tackle these global challenges.[9]

5. Analysis is done for 2022 as HEMIS data are not available for 2023. The researcher cohort refers to the headcount of all Permanent Instruction and Research Staff at public universities, while the second cohort is only those with a Doctoral degree.
6. NRF publication numbers may decline in the future given that WoS publications are counted for three years after grant funding to allow for publication timelines.
7. Singh, U.K. (2024) Sustainable Development Goals in South Africa: Progress and Challenges. Regional Dimensions of Human Development in India and South Africa: Through Sustainable Development Goals, pp.93-146.
8. Mthembu, D. and Nhamo, G., 2021. Landing the climate SDG into South Africa's development trajectory: Mitigation policies, strategies and institutional setup. Sustainability, 13(5), p.2991.
9. Nhamo, G. and Chapungu, L., (2024, May). Seven years of embracing the sustainable development goals: perspectives from University of South Africa's academic staff. In Frontiers in Education (Vol. 9, p. 1354916). Frontiers Media SA.

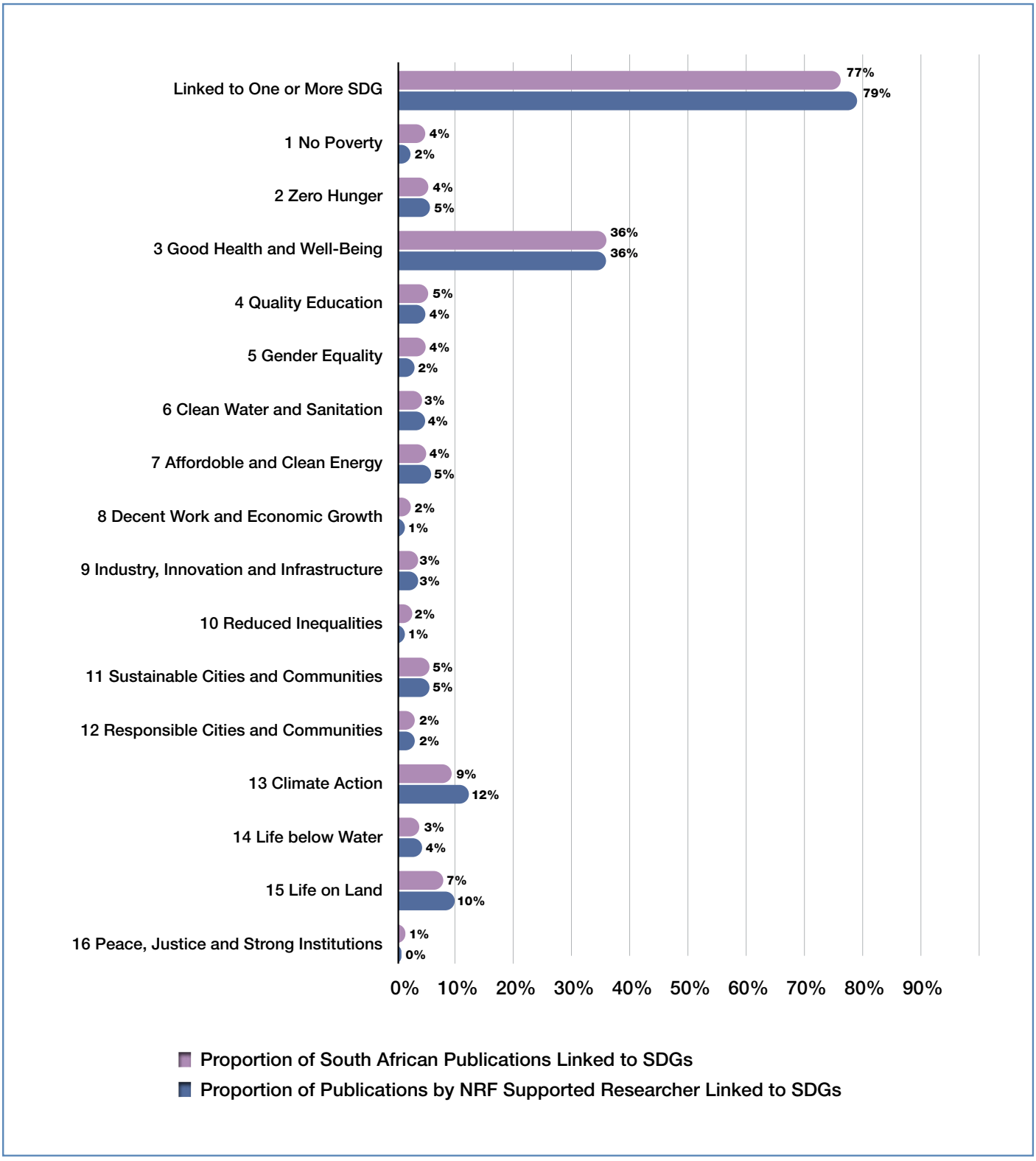
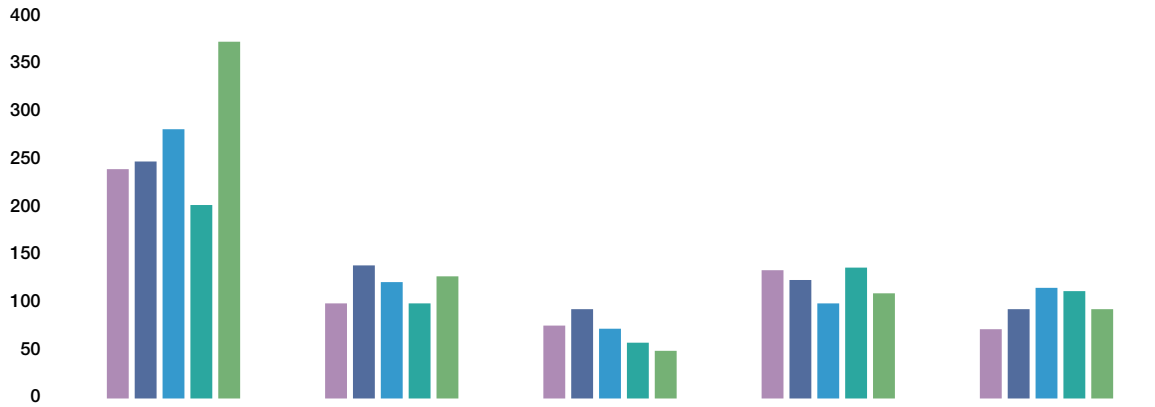


Figure 2: WoS Analysis of South African and NRF-funded Research Output Linked to SDGs, 2023

NRF National Research Facility publications

The NRF's National Facilities produce a considerable amount of research across their various specialised research fields and disciplines. Given their different knowledge domains, along with their different sizes and budgets, it is important to consider each facility individually. In addition, some focus more on WoS publications while others, given their research area, focus more on local journals, policy briefings, or similar publications to ensure local societal impact.

Overall, investment in National Research Infrastructure Platforms has grown from R1.3 billion in 2019/20 to R2.8 billion in 2023/24. A significant proportion has been capital expenditure, especially for the Square Kilometre Array (SKA), which will increase South Africa's research impact in the future. This significant development helps to ensure the availability of platforms for researchers and students. This has led to increased impact, growth in publications output, and the development of postgraduate students. The National Facilities' WoS research publications have increased from 637 in 2019 to 767 in 2023 (20% growth) as shown in Figure 3 below. This demonstrates the value of cutting-edge research infrastructure platforms for national research output. Despite these achievements, challenges have been experienced and sufficient funding is required to maintain and further develop research infrastructure.



	NRF-iThemba LABS	NRF-SAIAB	NRF-SAEON	NRF-SAAO	NRF-SARAO
2019	241	106	79	137	77
2020	250	142	96	130	94
2021	287	124	78	100	118
2022	210	105	64	143	116
2023	380	132	55	114	95

Figure 3: WoS Publications Emanating from the National Research Facilities, 2019 to 2023

South African Radio Astronomy Observatory (NRF-SARAO)

In 2023, there were 95 WoS publications with NRF-SARAO affiliated authors, declining from a high of 116 in 2022. Most radio astronomy research papers are produced by scientists who are not employed by NRF-SARAO, but who use the research platforms (mainly the MeerKAT telescope[10]) for scientific research. The National Facilities' scientists are primarily enablers of research through the provision of cutting-edge research platforms for the global research community. Given the trend in the astronomy sector towards big projects and international collaboration, such as MeerKAT, Southern African Large Telescope (SALT)[11], and the Square Kilometre Array (SKA), alternate measures of research productivity are also valuable.[12]

10. The South African MeerKAT radio telescope is a precursor to the Square Kilometer Array (SKA) telescope and will be integrated into the mid-frequency component of SKA, for more information see: https://www.sarao.ac.za/science/meerkat/about-meerkat/.
11. SALT is situated at the NRF-SAAO field station near Sutherland, in the Northern Cape, and is funded by a consortium of international partners including South Africa. It has been in full science operation since 2011. For more information see: https://www.salt.ac.za/.
12. For examples see the Declaration on Research Assessment (DORA, https://sfdora.org/) and the Leiden Manifesto.

The MeerKAT's scientific productivity is impressive for a complex instrument still in its infancy. This is largely due to its unique capabilities. Since the first paper based on the full MeerKAT array was published in September 2019 in *Nature*, 290 additional articles containing MeerKAT data have been published in the refereed literature. In qualitative terms, the MeerKAT continues to produce unique science. In the past year, the MeerKAT Team was recognised by the Royal Astronomical Society of London with its 2023 Group Achievement Award, *"…for a series of spectacular observations in radio astronomy, the highlight being the images of the Galactic Centre region and the spectacular radio bubbles. In addition, the MeerKAT team has supported the development of science and technology in Africa and stress-tested technology for the SKA."* A key publication highlight was the first publication from the MHONGOOSE Large Survey Project (LSP) in *Astronomy & Astrophysics* by a South African postdoctoral fellow with collaborators. It announced the possible detection, for the first time, of accretion of hydrogen gas onto a galaxy from the hypothesised cosmic web where galaxies reside. This contributes to one of the key unsolved mysteries in modern astrophysics, namely where do galaxies get their fuel to continue generating stars at the observed furious pace? No other telescope in the world has the ability to make these studies.

South African Astronomical Observatory (NRF-SAAO)

NRF-SAAO publications decreased in 2023 to 114, from a high of 143 in 2022. These WoS papers were produced using the NRF-SAAO telescopes, including SALT. NRF-SAAO is at the forefront of astronomical research, contributing significantly to our understanding of the Universe. Groundbreaking research, that has captivated the interest of both the scientific community and the public, is evident over the past five years. A few examples are mentioned below.

- **NASA's Double Asteroid Redirection Test Mission Collaboration (2022)** marked the first time humanity actively altered the course of a celestial body, setting a precedent for the protection of Earth from potential future asteroid threats.
- Researchers at the Max Planck Institute for Extraterrestrial Physics, in collaboration with South African astronomers, made a groundbreaking discovery using SALT. They **found a rare white dwarf binary system in the Large Magellanic Cloud**, which provided key insights into the explosive origins of supernovae.
- In a collaboration between the Hubble Space Telescope and SALT, **astronomers discovered an extremely metal-poor dwarf galaxy, named the 'Peekaboo' galaxy**. This discovery challenged existing theories of galaxy formation, providing a unique laboratory for astronomers to test theories about how the earliest galaxies in the Universe might have formed and evolved.
- **A Quadruple Star System was Discovered in 2022 using SALT and** the University of Canterbury's Mount John Observatory. It's a rare configuration, where two binary star systems orbited each other, suggesting that such systems could eventually lead to thermonuclear supernovae.
- In 2020 a study was published **unravelling the evolutionary stages of classical novae**, shedding new light on the debate surrounding the origins of three distinct types of classical novae. The collaborative research was led by former NRF-SAAO student, and included international teams from South Africa, the United Kingdom, Poland, and the Inter-University Centre for Astronomy and Astrophysics (IUCAA) in India, and utilised data from the SALT and Southern Astrophysical Research (SOAR) telescopes.
- A groundbreaking observation has **challenged previous theories about the Centaur asteroid Chiron**. Researchers, using the NRF-SAAO 1.9m telescope during a stellar occultation, observed evolving material orbiting Chiron, differing from the expected two-ring system. The findings suggest a dynamic environment around Chiron rather than the presence of a substantial global atmosphere as previously thought.
- One of the most remarkable discoveries by NRF-SAAO was a **group of extremely hot white dwarf stars**, identified using SALT. These stars are remnants of stars like our Sun that have exhausted their nuclear fuel and shed their outer layers, exposing their hot cores. The finding is crucial for understanding the life cycle of stars and the dynamics of stellar evolution.
- In a significant astronomical achievement, South African and international researchers collaborated to **discover the most distant megamaser observed**. The finding was facilitated by the MeerKAT telescope. The powerful megamaser, a type of radio-wavelength laser that indicates colliding galaxies, was identified by observing hydroxyl molecules within a galaxy merger emitting brightly due to the dense molecular gas created by the cosmic collision. Megamasers such as this one, named "Nkalakatha", provide crucial insights into the conditions and processes during galaxy collisions.

iThemba Laboratory for Accelerator Based Sciences (NRF-iThemba LABS)

NRF-iThemba LABS consistently has the highest proportion of National Facility WoS publications. Over the five-year period, publications have increased by 58% (241 to 380). One of the major experimental highlights during the period under review was the acceleration of the first radioactive ion beam on the front end test facility of the **Low-Energy Radioactive Ion Beam (LERIB)**. As part

of a collaborative research project with KU Leuven in Belgium, scientists at NRF-iThemba LABS successfully utilised a sample of potassium chloride enriched to 3% in radioactive isotope of potassium-40, yielding a total of 1 017 atoms of potassium-40, equivalent to 7 micrograms in weight. These were implanted into a glassy carbon disc to create a relatively pure potassium-40 target. The manufactured potassium target was used in an experiment at the Paul Scherrer Institute to measure the shifts for the muonic isotopes of potassium. The results signal major progress in unravelling the size of all the known potassium isotopes, from potassium-36 to potassium-52, with enhanced accuracy.

NRF-iThemba LABS scientists, in collaboration with Radiation Safety Health and Quality (RSHEQ) personnel, launched the integrated mobile gamma-ray detection system, deployed in a backpack arrangement. **The mobile gamma ray detection system** incorporates a sensitive scintillation detector (typically used for accelerator-based spectroscopy at the Separated Sector Cyclotron laboratory) into a backpack, incorporating a fast 125MHz digitiser for readout and a GPS enabled Raspberry Pi microprocessor system. This enabled in-situ measurements of radiation around the Cape Town site, with collected data streamed to the cloud and analysed offline. After conducting a series of rollout radiation measurement tests, the team used the gamma ray detection system, in collaboration with local and regional institutions, to take radiation monitoring measurements from calibrated sources in the field. Radiation measurement tests were conducted at the Kruger National Park and at mining areas in both South Africa and Botswana. The next phase of the project will be to miniaturise the weight of the gamma ray detection device so that it can be loaded on a drone to enable access to, and performance of, radiation monitoring measurements at remote sites.

In response to Covid-19, NRF-iThemba LABS researchers performed modelling to advance the safe use of drugs with superior antiviral properties to combat Covid-19. The study, 'First principle simulation of coated hydroxychloroquine on Ag, Au and Pt nanoparticles', was published in 2021. It explores the potential of these nanoparticles as drug delivery systems. This research could aid in the development of efficient and safe therapies by providing insights into the interaction between hydroxychloroquine and various nanoparticles.

South African Institute for Aquatic Biodiversity (NRF-SAIAB)

Steady publication output has continued at NRF-SAIAB, reaching 132 publications in 2023, a 25% increase since 2019. Performance is high when normalised for size and benchmarked against the National System of Innovation (NSI) showing the value of strong infrastructure, stable funding, bursaries, and a productive full-time research team supported by postdoctoral researchers and collaborative research partnerships.

A number of notable NRF-SAIAB book publications appeared in the period under review. The *Coastal Fishes of the Western Indian Ocean (CFWIO)*, a multi-authored, illustrated, five-volume publication on fish diversity, and *Fish & Fisheries in Estuaries – A Global Perspective*, were both published in 2022. The former is an invaluable tool for identifying fish species inhabiting the coastal waters of the Western Indian Ocean, spanning from the Red Sea to Cape Point, and from Kanyakumari to St Paul and Amsterdam Islands. It includes detailed keys, diagnoses, species descriptions, and illustrations. Published in 2019, *Fishes of Southern African Estuaries: From Species to Systems* is the culmination of 40 years of Professor Alan Whitfield's (NRF-SAIAB Chief Scientist Emeritus) dedicated research and more than a century's work by fish scientists who worked on various Southern African estuaries. Another top achievement was the publication of *Knysna Estuary – Jewel of the Garden Route*, which introduces readers to the multifaceted nature of the Knysna Estuary and how the biotic and abiotic components function together as a system.

NRF-SAIAB balances publications in journals (international and national) with technical briefs to support policy development. Outputs range from the foundational taxonomic disciplines, to ecological, functional, pollution, and climate change themes, linking knowledge with management, policy, and conservation. NRF-SAIAB thereby provides vital national scientific leadership and expertise in aquatic biodiversity to inform responses to issues arising from the increasing pressures of human population growth and infrastructure development. Building on the foundations developed from interdependent research areas, i.e. systematics and genetics, aquatic biodiversity and ecology, and applied conservation biology, NRF-SAIAB has become aligned with more demand-driven, collaborative research that supports national and international imperatives; including strategic targets of the National Development Plan (NDP), Marine and Antarctic Research Strategy (MARS), Phakisa Programme and the United Nations Sustainable Development Goals (SDGs). NRF-SAIAB works with partners to inform the ecologically, economically, and socially sustainable use of fisheries resources through surveys and data collection. In 2023, the Freshwater Research Unit completed a large joint research contract project that

generated the most comprehensive dataset to date on the distribution of Mozambique and Nile tilapia in the Limpopo, Mpumalanga and KwaZulu Natal provinces. This research is fundamental for informing inland fisheries and aquaculture development to address the triple challenges of food and nutrition insecurity, unemployment and equitable access to aquatic resources in the country.

South African Environmental Observation Network (NRF-SAEON)

NRF-SAEON's publications reached a peak of 96 in 2020 during the Covid-19 lockdown, which reduced fieldwork and gave scientists time to analyse existing datasets and write papers based on the results. There has since been a slight decline in the number of papers being published due to a focus on the implementation and deployment of instruments in different sites of the three research infrastructures hosted by NRF-SAEON. NRF-SAEON publications will increase overtime as the research infrastructures mature, and scientists have more time to focus on research. The platforms will also attract more users and collaborators.

There is also increased focus on societal impact in line with the NRF's research impact agenda. NRF-SAEON's collaborative nature and reputation are demonstrated by the fact that most publications are co-authored with non-SAEON scientists. The Facility prioritises knowledge geared towards policy making and societal impact, and it is well-positioned to provide dependable and long-term environmental observation data. NRF-SAEON is also focused on building a sustainable and transformed research workforce, with several former students appointed as full-time scientific staff members. NRF-SAEON's highlights are discussed below.

NRF-SAEON sites were identified strategically, for example, we re-established a dense network of hydro-climatological monitoring in 2012 in the Cathedral Peak research catchments which form part of the Northern Drakensberg Strategic Water Source Area in the upper uThukela catchment in KwaZulu-Natal. These catchments were monitored from 1949 to 1995, and by re-establishing and extending the monitoring record, NRF-SAEON provides insights into the impact of global change in this area, where there is a heavy dependence on the ecosystem services that this landscape provides at national, regional and local levels. The livelihoods of the local population are closely linked to the natural resources and ecosystem integrity. Research studies in the *Hydrological Sciences Journal* and *Journal of Hydrology: Regional Studies* have resulted from this project.

NRF-SAEON is the custodian of the Jonkershoek hydro climatological monitoring network. The network was established in 1936 to determine the impact of afforestation on water resources and stream flow. In 2021, a publication summarising the 80-year history of the Jonkershoek Hydro climatological monitoring network and NRF-SAEON's investment to upgrade the infrastructure was published in the *Hydrological Processes*. The network has provided much needed insight into the role of forestation on water resources and streamflow. In a water scarce country such as South Africa, information on land use and hydrological processes is extremely invaluable for decision makers. The data are openly available.

It is vital to monitor the Indian Ocean's state and its influence on climate and maritime resources, especially for those countries bordering its shores. However, the Indian Ocean Observing System (IndOOS) has faced challenges which have affected data reporting, particularly from key observational platforms measuring upper ocean heat variability. The impact of the observed data loss on weather and climate analyses and forecasts will be significant and must be addressed urgently.

Conclusion

Journal publications are a recognised format for research dissemination. Publications in quality journals highlight the productivity of the researcher cohort. In the South African context, growing our knowledge impact along with our societal impact is critical. By supporting researchers at different career stages, the NRF has helped to boost national research output, with a comparative analysis from 2020 to 2023 showing a positive trend for NRF-funded research. South African researchers are doing relatively well in responding to SDG challenges, but there needs to be more focus on South-Africa's particular challenges and ensuring that research is used for societal benefit.

National Facility research is growing, and key ground-breaking research is evident. The above analysis highlights the National Facilities' dual publication strategies, and the vital role that well-developed research infrastructure platforms play in advancing research and societal benefit. Overall, the NRF's contributions have not only advanced research output but also fostered the development of postgraduate students and ensured the availability of essential research platforms. Continued support and sufficient funding are crucial to maintaining and furthering these achievements.